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NASA TECH BRIEF

Lewis Research Center

Design Criteria Monograph on Turbopump Shafts and Couplings

A design criteria monograph has been published which is a summary and a systematic ordering of the large and loosely organized body of existing successful design techniques and practices for the design of liquid rocket engine turbopump shafts and couplings.

This monograph was written to organize and present, for effective use in design, the significant experience and knowledge accumulated by NASA in development and operational programs. It reviews and assesses current design practices, and from them establishes firm guidance for achieving greater consistency in design, increased reliability in the end product, and greater efficiency in the design effort.

Turbopump shafts and couplings are critical elements of rocket engine turbopumps. The achievement of adequate strength and fatigue life for these basic pump components has not been a major problem in design because power torque loads relative to shaft size generally have been low. However, the achievement of acceptable shaft dynamic characteristics has required major design and development programs. This monograph considers all aspects of turbopump system shaft dynamics peculiar to and necessary to shaft and coupling design. Associated components (bearings, housing, etc.) that influence the shaft or coupling design also are treated to the extent necessary to define that influence.

The analytical evaluation and prediction of shaft dynamics and critical-speed characteristics is one of the most important design tasks. Prediction accuracy is a function of the detail incorporated into the mathematical model and the capability of the computer program. Critical speeds must be appropriately considered and classified in importance if they are to be properly understood and treated in relationship to other design factors. Many types of forced and self-excited whirls occur in turbopumps, but forced synchronous whirls generally are the most important. The vibrational characteristics and critical-speed behavior of the shaft are covered extensively in this monograph; in addition, the techniques used to adjust critical speeds and response levels and to improve rotor balance are reviewed.

The monograph comprises two major sections: "State of the Art" and "Design Criteria and Recommended Practices." References complement the text.

The State of the Art section reviews and discusses the total design problem and identifies the design elements that are involved in successful design. The Design Criteria state clearly and briefly each rule, guide, limitation, or standard that must be imposed on each essential design element to assure successful design; the Recommended Practices set forth the best available procedures for satisfying the Design Criteria.

Both major sections are divided into four subject categories: Shaft Design (design parameters, materials, structural analysis, assembly and operation, and quality control), Shaft Dynamics (dynamic behavior, analysis of shaft dynamic behavior), Coupling Design (splines, curvic couplings, and parallel-sided face couplings), Design Confirmation Tests (nonrotating tests, rotating system tests, and special tests).

This thorough review of design criteria and practices relating to turbopump shafts and couplings should be useful for a wide range of shaft and coupling applications and should be of interest to manufacturers and users of pumps, power drives, turbine drives, and general rotary equipment.

Notes:

1. This monograph has been published as the following report:

   NASA SP-8101 (N74-14441), Liquid Rocket Engine Turbopump Shafts and Couplings

   Copies may be obtained at cost from:

   Aerospace Research Applications Center
   Indiana University
   400 East Seventh Street
   Bloomington, Indiana 47401
   Telephone: 812-337-7833
   Reference: B74-10014

(continued overleaf)

2. Specific technical questions may be directed to:
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